An impact analysis of Dallman Unit 4 boiler's metal emissions was made as part of the Additional Impacts Analysis (Part 7 of the PSD Permit Application, revised in June 2005) required by PSD regulations. This supplement discusses the impacts of emitted metals on soils and plants from the Dallman Unit 4 project and was accomplished using the EPA-approved protocol "Screening Level Ecological Risk Assessment Protocol for Hazardous Wasted Combustion Facilities, Chapter 3: Air Dispersion and Deposition Modeling".

In addition to criteria pollutants, other materials are present in the coal or can be formed as a by-product of combustion in the boiler and have the potential to be emitted in small quantities. The metal elements that can be emitted may have an adverse effect on plants and soils. Emission estimates for metals are based on emission factors taken from AP-42 Section 1.1, *Bituminous and Subbituminous Coal Combustion* (9/98). Several assumptions were made to allow for a "worst-case" calculation of emissions. It is assumed that the boiler will burn coal at the rate of 2,438 MMBtu per hour for the entire year (8,760 hours), and the firing process will release all of these contaminants contained in the coal. None of these pollutants were assumed to be entrained in the bottom ash and the control devices available will be the SCR, the wet FGD, and a fabric filter. In actuality, the unit will operate for less than 8,760 hours annually and some of the material will be captured in the bottom ash while other material will be more effectively removed in the SCR, wet FGD, and particulate control systems (fabric filter and wet electrostatic precipitator).

The emission rates of each of the metals that may be emitted from the Dallman Unit 4 boiler were modeled using the EPA-approved ISC model in the same manner as the criteria pollutants (described in Section 6 of the PSD Permit Application) and annual impacts were obtained for each. In addition, because deposition was used in the modeling process meteorological data along with some additional inputs into ISC needed to be adjusted according to the EPA's document, "Screening Level Ecological Risk Assessment Protocol for Hazardous Wasted Combustion Facilities". Meteorological data in ISC was determined using the following rural and grassland assumptions (tables can be found in Appendix A along with PCRAMET Log with these values):

- Monin-Obukhov Length: 25 meters for residential
- Anemometer height (known): 9.4488 meters

- Surface Roughness: 0.1 for grassland
- Albedo: 0.25875 average of the seasons for grassland (0.65 and 0.30 for winter)
- Bowen Ratio: 0.7 for grassland
- Anthropogenic heat flux: 0.0 for rural areas
- Net Radiation: 0.15 for rural areas

In addition to the meteorological data, deposition terms were associated into the model and included mean particle diameter (µg), fraction of total mass, density (g/cm^3) (assumed to be 1.0), and wet scavenging rate coefficient (hr/s-mm). The wet scavenging rate coefficient is a function of particle diameter. . The value is used for both liquid and frozen particle deposition.

Because the Dallman Unit 4 boiler has the potential to emit 99.99 percent of all HAPs emitted by this facility, only the metals, dioxins, and furans emitted from the Dallman Unit 4 boiler were included in this modeling. Metals present in the coal along with dioxins and furans are listed in Table 1 along with their emission factors and modeled ground level concentrations.

Table 1
Modeled Metal Emissions

Pollutant	Emission Rate* 100% Load on Coal (lb/hr)	Maximum Modeled Annual Ground Level Concentration ($\mu g/m^3$)
Arsenic	0.049	9.00×10^{-5}
Cadmium	0.006	1.00×10^{-5}
Chromium	0.031	6.00×10^{-5}
Cobalt	0.012	2.00×10^{-5}
Fluorides	0.596	1.12×10^{-3}
Lead	0.050	9.00×10^{-5}
Manganese	0.059	1.10×10^{-4}
Mercury	0.005	1.00×10^{-5}
Nickel	0.034	6.00×10^{-5}
Selenium	0.156	2.90×10^{-4}
Dioxins	2.93×10^{-5}	0.00
Furans	2.93×10^{-5}	0.00

* Based on AP-42: Table 1.1-18 and maximum coal rate of 120.0 tons/hr.

In determining the effects that the metals, dioxins, and furans have on the soil, the deposition concentration of the trace elements on soils were calculated by using the screening techniques described in the EPA's document, "Screening Level Ecological Risk Assessment Protocol for

Hazardous Wasted Combustion Facilities", Section 3.11.1 – Calculation of COPC Concentrations in Soil. The formula for calculating the soil concentration is as follows:

$$Cs = \frac{Ds \cdot [1 - \exp(-ks \cdot tD)]}{ks}$$

Where:

CS = COPC (compound of particular concern) concentration in soil (mg COPC/kg soil)

Ds = Deposition Term (mg/kg-yr)

ks = COPC soil loss constant due to all processes (yr^{-1})

tD= Total time period over which deposition occurs (yr, assume 100 yrs)

The deposition term (Ds) and soil lost constant (ks) are both calculated using more in-depth equations/variables which are included in Appendix A. After applying above equation to the ground level concentrations that were modeled, the soil concentration was compared to the acceptable background and screening levels designated by the EPA, both values in (mg/kg). The background concentrations were taken from Tiered Approach to Corrected Action Objectives (TACO) appendix presented by the Illinois EPA. The background concentrations are specific to Illinois and are different for metropolitan/non metropolitan counties. Sangamon County, where the facility is located, is considered metropolitan. Background levels are not available for the fluorides, dioxins, and furans.

The soil screening levels used were No Observed Adverse Effect Levels (NOAEL) and are specific to different animals. The screening levels were taken from the "Toxicology Benchmarks for Wildlife: 1996 revision" given to the U.S. Department of Energy. For this particular ecological risk, the animals in of concern are the bald eagle and Indiana bat. The closest species for the analysis for the metals was the Great Blue Heron. Screening levels were available for all metals from this document. For the dioxins, the NOAEL level of 2,3,7,8-Tetrachloro Dibenzodioxin (TCDD) for a Ring Necked Pheasant was used to represent the closest available species and was the worst-case screening level for dioxins. TCDD is also considered the most toxic of all dioxins and is commonly used as a reference for all other dioxins. For the furans, the NOAEL level of 2,3,7,8-Tetrachloro Dibenzofuran (TDBF) for a Great Blue Heron was used to represent the worst-case screening level for furans.

Table 2, below, indicates that the calculated depositions concentrations (mg/kg) from the modeled results are well below the standard screening level for each metal and dioxin/furans. Likewise, Table 2 indicates that the soil concentrations are well below the local background concentrations.

Table 2
Trace Concentration Compared to Screening and Background Levels

Pollutant	Maximum Modeled Deposition Concentration (mg/kg)	Screening Level (mg/kg)	Local Background Concentration (mg/kg)
Arsenic	0.115	5.1	13
Cadmium	0.003	1.45	0.6
Chromium	0.093	1	16.2
Cobalt	3.89×10^{-5}	0.14	8.9
Fluorides	0.0096	7.8	N/A
Lead	0.236	3.85	36
Manganese	0.001	997	636
Mercury	6.30×10^{-4}	0.45	0.06
Nickel	0.077	77.4	18
Selenium	0.253	0.5	0.48
Dioxins	2.01×10^{-9}	1.40×10^{-5}	N/A
Furans	1.94×10^{-11}	1.00×10^{-6}	N/A

Pollutant	Emission Rate		
	lb/hr	tpy	(g/s)
Arsenic	4.92E-02	2.15E-01	6.20E-03
Cadmium	6.12E-03	2.68E-02	7.71E-04
Chromium	3.12E-02	1.37E-01	3.93E-03
Cobalt	1.20E-02	5.26E-02	1.51E-03
Fluorides (Chlorine)	5.96E-01	2.61E+00	7.51E-02
Lead	5.04E-02	2.21E-01	6.35E-03
Manganese	5.88E-02	2.58E-01	7.41E-03
Mercury	5.25E-03	2.30E-02	6.61E-04
Nickel	3.36E-02	1.47E-01	4.23E-03
Selenium	1.56E-01	6.83E-01	1.97E-02
Dioxins	2.93E-05	1.28E-04	3.69E-06
Furans	2.93E-05	1.28E-04	3.69E-06

	Appendix A-2 Variables for each Metal (and Dioxins/Furans)						
Pollutant	Fv	Kds (pH=6.8) (cm^3/g)	Da (cm^2/s)	H (atm m^3/mol)	Source		
Arsenic	0.00	29.00	0.1070	0.00	Appendix A-2, Table A-2-14, Page A-2-49		
Cadmium	0.00	75.00	0.0816	0.00	Appendix A-2, Table A-2-35, Page A-2-71		
Chromium	0.00	1.80E+06	0.1010	0.00	Appendix A-2, Table A-2-52, Page A-2-89		
Cobalt	0.00	0.00	0.0000	0.00	None, Fv & H Assumed for all metals		
Fluorides (Chlorine)	1.00	0.00	0.1100	0.00	Appendix A-2, Table A-2-39, Page A-2-75		
Lead	0.00	900.00	0.0543	0.00	Appendix A-2, Table A-2-128, Page A-2-169		
Manganese	0.00	0.00	0.0000	0.00	None, Fv & H Assumed for all metals		
Mercury	1.00	1000.00	0.0109	7.10E-03	Appendix A-2, Table A-2-131, Page A-2-172		
Nickel	0.00	65.00	0.1260	0.00	Appendix A-2, Table A-2-145, Page A-2-186		
Selenium	0.00	5.00	0.1030	0.00	Appendix A-2, Table A-2-172, Page A-2-215		
Dioxins	0.49	9.77E+05	0.0127	1.60E-05			
Furans	1.00	3.72E+06	0.1310	5.30E-05			

Fv: Fraction of COPC air concentration in vapor phase
Kds (cm^3/g): soil-water partition coefficient
Da (cm^2/s): Diffusivity of COPC in air
H (atm m^3/mol) Henry's Law Constant

Variables for all Metals		Units	Source
tD time period	100	yr	Appendix B, Table B-1-1, Page B-3
Zs: Soil Mixing Depth (assumed Tilled)	20	cm	Appendix B, Table B-1-1, Page B-4
BD: Soil Bulk Density	1.5	g/cm^3	Appendix B, Table B-1-1, Page B-4
Vdv: Dry Deposition Velocity	3	cm/s	Appendix B, Table B-1-1, Page B-5
Kse: loss constant due to erosion	0	1/yr	Appendix B, Table B-1-3, Page B-14
θsw: Soil volumetric water constant	0.2	mL/cm^3	Appendix B, Table B-1-4, Page B-21
R : Universal Gas Constant	8.205E-05	atm-m^3/mol-K	Appendix B, Table B-1-6, Page B-32
Ta: Ambient Air Temperature	298	K	Appendix B, Table B-1-6, Page B-32
ρs: Solids Particle Density	2.7	g/cm^3	Appendix B, Table B-1-6, Page B-33
RO: Average annual surface runoff	25.4	cm/yr	USGS Map
P: Average Annual Precipitation	90.32	cm/yr	National Weather Service
I: Average Annual Irrigation	0	cm/yr	Per Don Pitts at Illinois Department of Water
Ev: Average Annual Evapotranspiration	76.2	cm/yr	USGS Map

Equations

$$Cs = \frac{Ds \cdot [1 - \exp(-ks \cdot tD)]}{ks}$$ concentration in soil (mg/kg)

$$Ds = \frac{100 \cdot Q}{Z_s \cdot BD} \cdot [F_v (0.31536 \cdot Vdv \cdot Cyv + Dywv) + (Dydp + Dywp) \cdot (1 - F_v)]$$ Deposition term (mg/kg-yr)

KS = Ksg +Kse + Ksr +Ksl +Ksv — soil loss constant due to all processes (1/yr)

Ksg = 0 For All Metals — loss constant due to abiotic and biotic degradation (1/yr)

Kse= 0 For Metals and Dioxins/Furans — loss constant due to soil erosion (1/yr)

$$ksr = \frac{RO}{\theta_{sw} \cdot Z_s} \cdot \left(\frac{1}{1 + (Kd_s \cdot BD / \theta_{sw})} \right)$$ loss constant due to surface runoff (1/yr)

$$ksl = \frac{P + I - RO - E_v}{\theta_{sw} \cdot Z_s \cdot [1.0 + (BD \cdot Kd_s / \theta_{sw})]}$$ loss constant due to leaching (1/yr)

$$ksv = \left[\frac{3.1536 \times 10^7 \cdot H}{Z_s \cdot Kd_s \cdot R \cdot T_a \cdot BD} \right] \cdot \left(\frac{D_a}{Z_s} \right) \cdot \left[1 - \left(\frac{BD}{\rho_s} \right) - \theta_{sw} \right]$$ loss constant due to volatization (1/yr)

Pollutant	Cyv (µg/m^3)	Deposition Dywp + Dydp g/m^2-yr	Dywv (g/m^2-yr)	Comments
Arsenic	9.00E-05	0.11181	0	Zero since Fv is zero
Cadmium	1.00E-05	0.01391	0	Zero since Fv is zero
Chromium	6.00E-05	0.07091	0	Zero since Fv is zero
Cobalt	2.00E-05	0.02727	0	Zero since Fv is zero
Fluorides	1.12E-03	1.35405	1.35405	Modeled
Lead	9.00E-05	0.11454	0	Zero since Fv is zero
Manganese	1.10E-04	0.13363	0	Zero since Fv is zero
Mercury	1.00E-05	0.01193	0.01193	Modeled
Nickel	6.00E-05	0.07636	0	Zero since Fv is zero
Selenium	2.90E-04	0.35454	0	Zero since Fv is zero
Dioxins	0.00E+00	0.00007	0.00007	Modeled
Furans	0.00E+00	0.00007	0.00007	Modeled

Cyv: Maximum Modeled Annual Ground Level Concentration (µg/m^3)

						With Depletion					
Pollutant	Ksr (1/yr)	Ksl (1/yr)	Ksv (1/yr)	Ksg (1/yr)	KS (1/yr)	DS (mg/kg-yr)	CS (mg/kg)	Background Concentration (mg/kg)	Screening Levels (mg/kg)	Exceed Background?	Exceed Screening?
Arsenic	2.91E-02	-1.29E-02	0.00E+00	0.00	1.62E-02	2.31E-03	1.15E-01	13	5.1	no	no
Cadmium	1.13E-02	-5.00E-03	0.00E+00	0.00	6.27E-03	3.58E-05	2.66E-03	0.6	1.45	no	no
Chromium	4.70E-07	-2.09E-07	0.00E+00	0.00	2.62E-07	9.29E-04	9.29E-02	16.2	1	no	no
Cobalt	6.35E+00	-2.82E+00	0.00E+00	0.00	3.53E+00	1.37E-04	3.89E-05	8.9	0.14	no	no
Fluorides	6.35E+00	-2.82E+00	0.00E+00	0.00	3.53E+00	3.39E-01	9.60E-02	N/A	7.8	N/A	no
Lead	9.41E-04	-4.18E-04	0.00E+00	0.00	5.23E-04	2.42E-03	2.36E-01	36	3.85	no	no
Manganese	6.35E+00	-2.82E+00	0.00E+00	0.00	3.53E+00	3.30E-03	9.35E-04	636	997	no	no
Mercury	8.47E-04	-3.76E-04	4.07E-02	0.00	4.11E-02	2.63E-05	6.30E-04	0.06	0.45	no	no
Nickel	1.30E-02	-5.77E-03	0.00E+00	0.00	7.23E-03	1.08E-03	7.67E-02	18	77.4	no	no
Selenium	1.65E-01	-7.32E-02	0.00E+00	0.00	9.17E-02	2.32E-02	2.53E-01	0.48	0.5	no	no
Dioxins	8.67E-07	-3.85E-07	1.09E-07	0.429	4.29E-01	8.61E-10	2.01E-09	N/A	1.40E-05	N/A	no
Furans	2.28E-07	-1.01E-07	9.81E-07	44.3	4.43E+01	8.61E-10	1.94E-11	N/A	1.00E-06	N/A	no